Environmental Management Technology Demonstration and Commercialization Under the FETC–EERC EM Cooperative Agreement

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I. Introduction

Successful implementation of the Department of Energy (DOE) Environmental Management (EM) Program's 2006 Plan will require the timely deployment of cost-effective, efficient, and safe cleanup technologies within the DOE complex. The Energy & Environmental Research Center (EERC), a nonprofit, contract-supported research, development, demonstration, and commercialization (RDD&C) unit of the University of North Dakota, is entering the fourth year of a Cooperative Agreement with the DOE Federal Energy Technology Center (FETC) designed to expedite technology deployment through a combination of services including technical support, demonstrations, and brokering. This paper profiles current activities under the FETC–EERC EM Cooperative Agreement and details the part the Cooperative Agreement plays in meeting EM goals.

II. FETC–EERC EM Cooperative Agreement: Concept and Approach

Technology commercialization can be hampered by limited capabilities for testing and demonstration, limited capital, and, specific to the EM Program, a limited knowledge of DOE and EM site needs. In other cases, commercial-ization may hinge on the successful resolution of technical issues outside the traditional focus of the technology developer. Deployment of the technology in the highly competitive EM marketplace requires sound data from field tests that clearly demonstrate the superior capabilities of the technology, knowledge of site plans and personnel, and the potential to incorporate the technology into the ongoing site cleanup activities with minimal disruption.

Under the FETC–EERC EM Cooperative Agreement, the EERC is able to provide up to $150,000 annually in services geared toward minimizing commercialization barriers through focused technical assistance, partnership brokering, and demonstrations. In order to accomplish this mission, the EERC continually seeks to match its core capabilities with the needs of promising technologies (i.e., tech-nologies at a minimum of Gate 3 with the potential for wide application within the complex). Once a candidate activity is identified, the EERC works with the technologist to develop a proposal for services which is submitted for FETC approval. Competitive advantage is protected through proven confidentiality agreements.

The EERC features a multidisciplinary staff of over 120 full-time science and engineering professionals and a dedicated 169,000-sq ft facility which houses offices as well as a broad range of analytical, testing, and demonstration capabilities. Tests and demonstrations represen-tative of a wide range of conditions can be undertaken at the laborabory to pilot scale. The EERC currently has major programs in mercury control and remediation, water and waste treat-ment, air toxics sampling and control, and site

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characterization. Systems engineering capabilities are also available for performance and costing assessments.

Regulatory constraints and liability concerns can create barriers to field site access for demonstrations. The EERC's growing family of industrial partners provides the potential for access to a wide variety of technology demonstration sites. For example, the EERC has access to a remediation demonstration site in Alberta, Canada, through a relationship with the Canadian Association of Petroleum Producers, Gulf Canada, and the DOE Jointly Sponsored Research Program. Further, the EERC has an established track record for scientifically sound field test design, oversight, and evaluation.

In order to meet the needs of the 2006 Plan, technologies must be successfully deployed at EM sites. Under the Cooperative Agreement, the EERC works as an active partner to understand site issues and technology needs, to support development of the information packages required by client sites for the evaluation and deployment of technologies, and to support deployment-brokering activities.

III. Commercialization Activities

In 1997, the third year of the Cooperative Agreement, the EERC provided services to eight technologists. Work on tasks active in Year 3 is summarized below by task.

Task 2 – Extraction and Analysis of Pollutant Organics. A prototype instrument for performing SFE (supercritical fluid extraction) with on-line FT-IR (Fourier transform infrared spectrometry) detection was developed, tested, and brought to the point of final evaluation by Suprex Corporation, a leading SFE instrument supplier. In the fall of 1996, Suprex, the EERC's industry partner in the project, was bought out by ISCO Corporation, its leading competitor, and as a result, the SFE/FT-IR project was terminated.

The SFE/FT-IR method, which is capable of providing quantitative and compound-class analysis for virtually all types of organic compounds at sensitivities of parts per million, is particularly advantageous for analyzing hazardous mixed wastes contaminated with radionuclides, since it generates no waste solvents. Analyses can be performed on solids and sludges included in DOE's EM Focus Areas concerned with Subsurface Contaminants; Mixed-Waste Characterization, Treatment, and Disposal; and Decontamination and Decommis-sioning.

Task 9 – Centrifugal Membrane Filtration. Beginning in 1995 with an assessment of opportunities based on information available on wastes in the DOE inventory and focused testing to demonstrate technology effectiveness, the EERC has worked toward the EM deployment of the centrifugal membrane filtration technology developed by SpinTek Membrane Systems, Inc., of Huntington Beach, California. This novel process uses supported ultrafiltration plates revolving at high rpm to separate suspended and colloidal solids from liquid streams, yielding a solids-free liquid stream and highly concentrated solids. This is a crosscutting technology that falls under the Efficient Separations and Processing Crosscutting Program, with potential application to tank wastes, contaminated groundwater, and secondary liquid waste streams from other remediation processes, including D&D systems.

During 1997, activities focused on enhancing the filtration performance. This was accomplished through the development and fabrication of alternative turbulence promoter designs and then testing and comparison of alternative and conventional designs using a statistically designed test matrix.

1998 activities will focus on determining the feasibility of coupling the SpinTek technology with the 3M Empore filter technology.

Task 12 – Laser Cleaning of Contaminated Painted Surfaces. The EERC is supporting F2 Associates of Albuquerque, New Mexico, in its development of a laser-based coating removal system for DOE's D&D focus area by 1) facilitating selection of on-line sensors and 2) developing a generic cost model for comparing competing surface-cleaning technologies.

With the completion of the on-line sensor work in 1996, the focus of 1997 activities was the development of a software tool for selecting a surface decontamination technique. Development of this product involved

1) compilation of a database from literature sources for various competing methods and 2) development of a decision tree outlining considerations involved in systematically evaluating cost and performance. The model was developed to fit within a systems engineering framework that evaluates technologies in reference to users' operational needs, technology costs, and capabilities. Some of the design- and application-dependent factors included in the surface-cleaning decision tree are the size and composition of the surface, levels of radioactivity and hazardous contaminants, cleaning capabilities of the technology, real-time measurement and control, utility requirements, stage of technology development, capital and operating costs, properties of the waste generated, waste disposal or recycling methods and costs, and postcleaning decontamination of the cleanup equipment.

Task 13 – Calibration and Field-Testing of a Fiber-Optic/Cone Penetrometer System for Subsurface Heavy Metals Detection. The EERC has teamed with Science and Engineering Associates of Albuquerque, New Mexico, to advance the development and demonstration of a heavy metal sensor based on the integration of fiber optics, LIBS (laser-induced breakdown spectroscopy), and cone penetrometry that can analyze the heavy metal content of the subsurface in situ. During 1997, activities focused on 1) calibration and validation of the LIBS probe and 2) development of multivariate models for subsurface matrix effects on the LIBS calibration. A review of the literature and the identification of ten potential non-DOE field demonstration sites were carried out as initial steps.

Under the first activity, reference values and concentration values for LIBS calibration were determined using data on the metal content of 60 sediment samples at two sites near Butte, Montana, and LIBS tests were performed in the laboratory on soil–heavy metal mixtures prepared using an EERC-developed technique. Spiked soil samples prepared using the procedure developed at the EERC showed good ability to produce quantitative mixtures of the spike solution containing heavy metals and the baseline soils.

Under the second activity, the results of a preliminary study using principal component analysis (PCA) of LIBS data obtained on three sets of Cr-spiked samples (i.e., 35, 75, and 150 mg) indicated that PCA modeling allowed the spectrum of the baseline soil to be reconstructed in all cases and that the first principal component has good correlation with the Cr concentration of the soil.

1998 activities will include technical support for a field demonstration at Hanford.

Task 14 – Bubbleless Gas Transfer. Chlorinated hydrocarbons represent one of the most important classes of pollutants at DOE sites. Highly chlorinated aliphatics such as tetrachloroethylene (PCE), trichloroethylene (TCE), and carbon tetrachloride cannot be degraded by typical processes, but can be degraded by a process called reductive dehalogenation. This process occurs under anaerobic conditions characterized by an abundance of electron donors and a paucity of electron acceptors. The addition of hydrogen gas supplies electrons without supplying carbon, resulting in the growth of the optimal microorganisms for remediation. Bubbleless gas transfer, a commercial technology used in non-EM applications, has the potential to effectively supply hydrogen to the subsurface because it allows for the direct dissolution of hydrogen into groundwater through the use of modules containing sealed, hollow, gas-permeable fibers filled with pure hydrogen under pressure.

The EERC has teamed with Baumgartner Environics of Olivia, Minnesota, to perform bench-scale column and batch tests in the laboratory to determine the applicability of this technology to in situ remediation activities.

Task 15 – Remediation of Organically Contaminated Soil Using Hot/Liquid (Subcritical) Water. Current remediation technologies for semivolatiles in soil are expensive, time-consuming, and often generate additional wastes. Although liquid water is normally considered too polar a solvent to be effective for the removal of organic contaminants from soils, the EERC has demonstrated that the solvent properties of liquid water can be changed from very polar at ambient conditions to those resembling the behavior of an organic solvent (e.g., ethanol or acetonitrile) by simply raising the temperature. The EERC has exploited this unique property of water in a technology using hot/liquid (subcritical) water for the remediation of soils contaminated with organics such as PAHs (polycyclic aromatic hydrocarbons), PCBs (polychlorinated biphenyls), and pesticides, as well as mercury.

During 1997, the EERC built and successfully tested a reliable laboratory-scale system to perform the optimization studies. The system, designed to allow the determination of complete mass balances, uses 10-gram samples and incorporates a heated solvent collection device, which allows the collection of pollutants that are extracted from the system. An 8-liter pilot-scale system appropriate for use in the laboratory or in the field was designed, constructed, and operated successfully. Preliminary systems analysis work has indicated that the technology is economically feasible.

The EERC has signed a confidentiality agreement with the 3M Corporation of St. Paul, Minnesota, to allow the consideration of 3M's new sorbent wastewater cleanup technology as an in-line method for separation of pollutants from extractant wastewater. 3M has expressed a high degree of interest in joint development of the subcritical water extraction technology and 3M's wastewater sorbents. In addition, the EERC has signed agreements with Western Environmental Services & Technology Inc. (WEST), a small business, for technology development and demonstration to address pesticide-contaminated soils and with AGSCO, another small business, for the demonstration of the technology on pesticide-contaminated water and soils.

Task 16 – Preparation of Sampling, Analysis, and Availability Assurance Plans for the Vortec Vitrification Demonstration Plant. The Vortec cyclone melting system® (CMS) facility at the DOE Paducah Gaseous Diffusion Plant is designed to treat soil contaminated with low levels of heavy metals and radioactive elements as well as organic wastes. The EERC was contacted by Vortec Corporation of Collegeville, Pennsylvania, to help in the development of sampling plans at the $11 million, 30-ton per day demonstration plant. The EERC has prepared QA/QC (quality assurance/quality control) sampling and analysis plans as a basis for determining compliance with the U.S. Environmental Protection Agency guidelines for emissions and the leachability of vitrified materials. The EERC also prepared a plan for testing and modeling of refractory corrosion, glass viscosity, and deposit formation to provide input for sound operating procedures. The plans address considerations for gas streams, feedstocks, vitrified materials, and wastewater.

Task 17 – Use of Acoustic Energy and Humic Acids to Mobilize Dense Nonaqueous-Phase Liquids (DNAPLs) from the Subsurface. The need for DNAPL mobilization and remediation is widespread in the DOE complex, and Weiss Associates of Emeryville, California, has developed an acoustic technology for DNAPL mobilization. The EERC has teamed with Weiss to test the feasibility of coupling the Weiss technology with the use of an environmentally safe humic acid surfactant developed by the EERC in order to enhance DNAPL mobilization and facilitate remediation. Since the task received preliminary approval from FETC in June 1997, activities have focused on preparations for laboratory testing at the EERC.

IV. Summary

Under an EM Cooperative Agreement with FETC, the EERC has instituted "hands-on" focused technical support, partnership brokering, and field demonstrations that provide a vehicle for rapid commercialization and deployment. The EERC plays a vital role in this process through its technical expertise, state-of-the-art facilities, growing family of government and commercial partners, and access to field demonstration sites. This approach removes barriers between government and the private sector and between the technologist and the client EM sites. As a result, parties in the public and private sectors can function as true partners in the commercialization and deployment process. The search for additional candidate technologies and commercial partners is ongoing.

V. Acknowledgments

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